Diapycnal Mixing in a Coastal Regime – AESOP

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LONG-TERM GOALS

To identify the major processes producing mixing in the upper ocean and to understand their dynamics sufficiently well to permit accurate parameterization of mixing for use in numerical models.

OBJECTIVES

These measurements during August 2006 were the first attempt we know of to survey a coastal domain with sufficient coverage to assess how mixing levels vary across the domain. Previous measurements have been concentrated in sub-regions, often revealing particular mixing processes, but insufficient to represent mixing throughout a regional model.

APPROACH

We ran lines of microstructure profiles 5-10 km long (Fig. 1), balancing needs for rapid temporal sampling against spatial windows containing at least some structure. Staying with each line for 12.5 hours resolved changes produced by the M2 twice-daily tide, and some lines were rerun at different phases of the monthly tide. As we began to understand patterns of tidal currents and mixing, the original set of lines was modified to reveal pulsing of water in and out of the large canyon splitting the bay down its middle. Powerful Doppler sonars installed on R/V Revelle by Rob Pinkel at Scripps, provided excellent velocity records, supplemented by a 300 kHz ADCP we installed on the bottom the bay's southern half.

WORK COMPLETED

Gregg and Horne (2009) examine mixing in aggregations of fish, probably anchovies, found in the bay. Turbulence was intense, with most dissipation rates at 10^{-6} to 10^{-5} W kg^{-1}, but mixing efficiences were very low, typically 0.002 compared with 0.2 in turbulent patches produced by shear instabilities. As a result, even though fish schools contributed half of the average dissipation, they made no significant difference in average diapycnal diffusivity. This, however, is a consequence of background diffusivitits averaging ten times those found earlier on the New England continental shelf, also during late summer.

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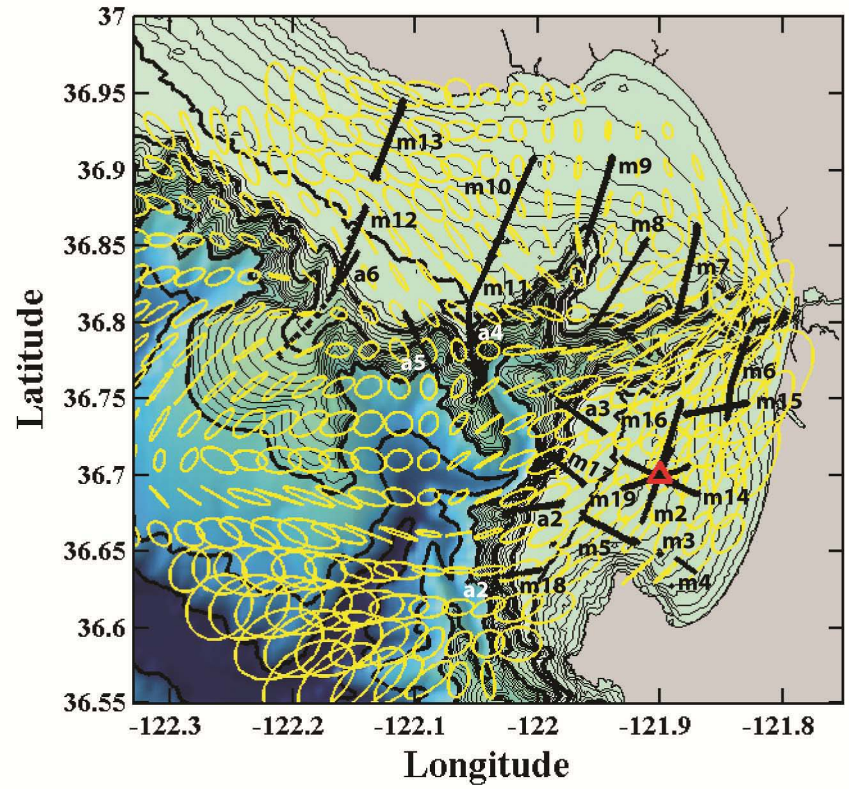

Fig. 1 MMP (m) and AMP (a) sampling groups in Monterey Bay, overlaid with tidal ellipses. A 300 kHz ADCP was mounted on the bottom at the red triangle. Thin shallow bathymetry contours are at 10 m intervals, and dark contours mark 100 m intervals.

RESULTS

Presently, we are trying to identify other mixing processes in the bay and use that to understand the levels and patterns, then comparing these results with those from other continental shelves. As an example of the patterns, not yet understood, Figure 2 compares average diapycnal diffusivities for MMP groups 10 and ll. Group 10 increases only slightly with depth, whereas group 11 increase much more strongly, reaching 10^{-2} m^2 s^{-1} at the bottom, compared to only one tenth that at the bottom of group 10. These two groups span most of the range of MMP averages.

The major puzzle is why levels are so much higher than on the New England shelf, as overall internal waves are consistent with Levine's (2002) adaptation of Garrett and Munk's (1975) internal waves (Fig. 3). This modification provides a natural reference for internal wave fields in shallow water.

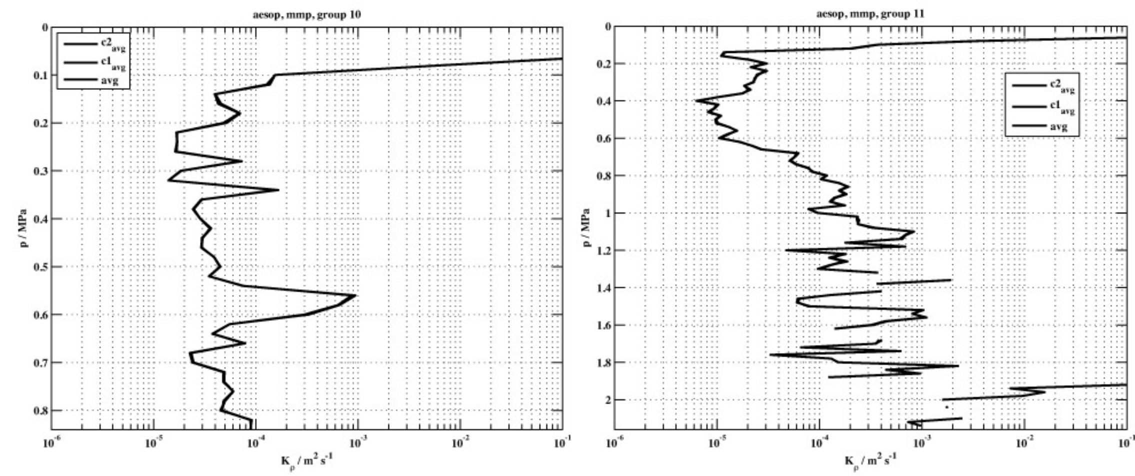

Fig. 2 Average diapycnal diffusivities for mmp groups 10 (left) and 11 (right)

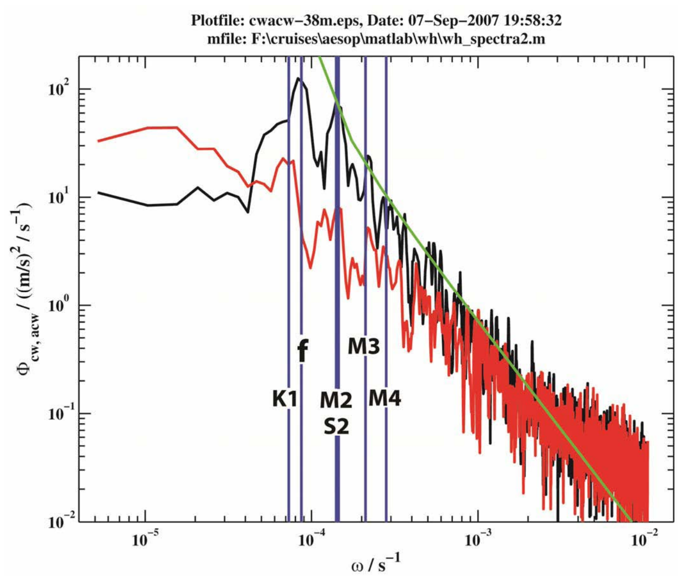

Fig. 3 Clockwise (black) and counter-clockwise frequency spectra at 38 m from the 300 kHz ADCP mounted on the bottom. Levine's spectrum is shown by the green line, and blue lines mark inertial and tidal frequencies.

IMPACT/APPLICATIONS

Gregg and Horne (2009) provide the first observations of turbulence within aggregations of fish, demonstrating that in at least some cases mixing efficiency is much lower than assumed by estimates that biomixing may be a major mixing process.

RELATED PROJECTS

These data, being analyzed in parallel with observations from the Black Sea, Aegean, and Philippines, should bound levels of mixing and processes in coastal regimes, information needed to convince modelers that mixing varies significantly enough to warrant allowing for this in numerical simulations.

MOST SIGNIFICANT ACCOMPLISHMENT

Quantifying mixing intensities and efficiencies with a fish aggregation.

PUBLICATIONS

Gregg, M.C. and J.K. Horne, Turbulence, acoustic backscatter and pelagic nekton in Monterey Bay, *J. Phys. Oceanogr*, 39, 1097-1114, 2009.